



Purdue QuarkNet Workshop 2013

Purdue University
Department of Physics
June 24-28, 2013

Schedule

- Monday:
 - Introduction to QuarkNet
 - Exercise: radioactivity / nuclear industry / particle accelerators
 - Cloud chamber activity
 - Lunch presentation (David Koltick)
 - Radioactive source activity
 - Discussion
- Tuesday:
 - Coincidence rate activity
 - Discussion
 - Contemporary Cosmic Ray Physics
 - Lunch presentation: Balloon experiment presentation (Jones)
 - E-labs: preparing posters
 - Activity: cosmic ray flux measurements
 - Tour of reactor facility
- Wednesday:
 - Discussion: measuring speed
 - Exercise: measuring speed of muons
 - Discussion
 - Lunch presentation: Isotope dating applications (Marc Caffee)
 - Discussion: measuring muon lifetime
 - Exercise: measuring muon lifetime
- Thursday:
 - Discussion: lifetime
 - Standard Model presentation
 - Lunch presentation: Dark matter (Rafael Lang)
 - CMS E-lab (Ken Cecire)
- Friday:
 - CMS E-lab (Ken)

What is QuarkNet?

<http://quarknet.fnal.gov/index.html>

- Principal Investigators:
 - Marjorie Bardeen (Fermilab)
 - Anna Goussiou (Washington)
 - Dan Karmgard, Mitch Wayne (Notre Dame)
- Staff Teachers:
 - Tom Jordan (Florida)
 - Ken Cecire (Notre Dame)
 - Bob Peterson (Fermilab)
- And many more...



QuarkNet: The science connection you've been waiting for!

The Opportunity: "Your program rejuvenates my soul. It connects me with a cadre of intelligent and excited educators. It reinvigorates my teaching and provides me avenues to extend and enliven the projects that I can offer my students. Without the Quarknet program I am sure that I would have left teaching years ago."

The Players: High school students, teachers and physicists working together on physics research projects exploring the hidden nature of matter, energy, space and time.

The Questions: What are the origins of mass? Can the basic forces of nature be unified? How did the universe begin? How will it evolve?

LHC & Fermilab Links

[CERN Homepage](#)
[ATLAS Experiment](#)
[CMS Experiment](#)
[LHCb Experiment](#)

[Fermilab Homepage](#)
[CDF Experiment](#)
[DZERO Experiment](#)

For Teachers

[QuarkNet Classroom Activities](#)

[Cosmic Ray e-Lab](#)
[CMS Ray e-Lab](#)
[LHC Workshop Resources](#)
[CMS Masterclass Library](#)
[Online Resources](#)
[Centers](#)

[Contact us!](#)

[Join us !](#)

For Students

[Cosmic Ray Studies](#)
[CMS Studies](#)
[Run II Website](#)
[View student Webcasts](#)
[Analyze the data](#)
[Measuring Single Photons](#)
[Discovering New Particles](#)
[Applying Ohm's Law](#)
[The Particle Adventure](#)
[The Top Quark](#)
[Online References](#)

[Project Overview](#)

[Kudos for QuarkNet](#)

[At Work](#)



This project is supported in part by the National Science Foundation and the Office of High Energy Physics, Office of Science, U.S. Department of Energy.

Opinions expressed are those of the authors and not necessarily those of the Foundation or Department.

What is QuarkNet?

(my own thoughts)

- One area of leading edge research into the fundamental laws of nature is ***Particle Physics...***
- And in particular, ***High Energy Physics (HEP)***
- As researchers, we get to...
 - Ask big questions like
 - “What is the origin of mass?”
 - “Where is all the anti-matter in the universe?”
 - Develop new technologies for conducting leading edge experiments
 - Carry out some of the most complex experiments ever constructed
 - Collaborate with hundreds or thousands of other researchers from around the world
- This creates some unique opportunities...

What is QuarkNet?

- High school outreach:
 - Valued and supported by the National Science Foundation (NSF)
 - Community benefits from publically funded research
 - Attract students to pursue careers in science and technology
 - **“QuarkNet: Helping Develop America's Technical Workforce”**
 - Leading edge research is *not* abstract – it is happening now in your community
 - You and your students can be a part of it!
 - You are not on your own:
 - 18 HEP experiments
 - 475 high schools in 24 states
 - 60,000 students per year
 - We can help you!

QuarkNet



[QuarkNet](#) is a national program sponsored by the [National Science Foundation](#) and the [U.S. Department of Energy](#), designed to involve high school physics and chemistry teachers in cutting-edge high energy particle physics research. Teachers work together to develop curriculum which can be incorporated into their teaching; thus, exposing students to the physics and technology of particle physics.

Particle Physics Experiments

- Accelerator based experiments:



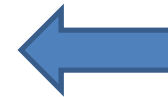
Fermilab (Batavia, Illinois)



CERN (near Geneva, Switzerland)

- Not very easy to put these in your classroom...

Particle Physics Detectors



CDF detector at Fermilab
which you and your class
can visit

CMS detector at CERN



Also not easy to put in your
classroom...

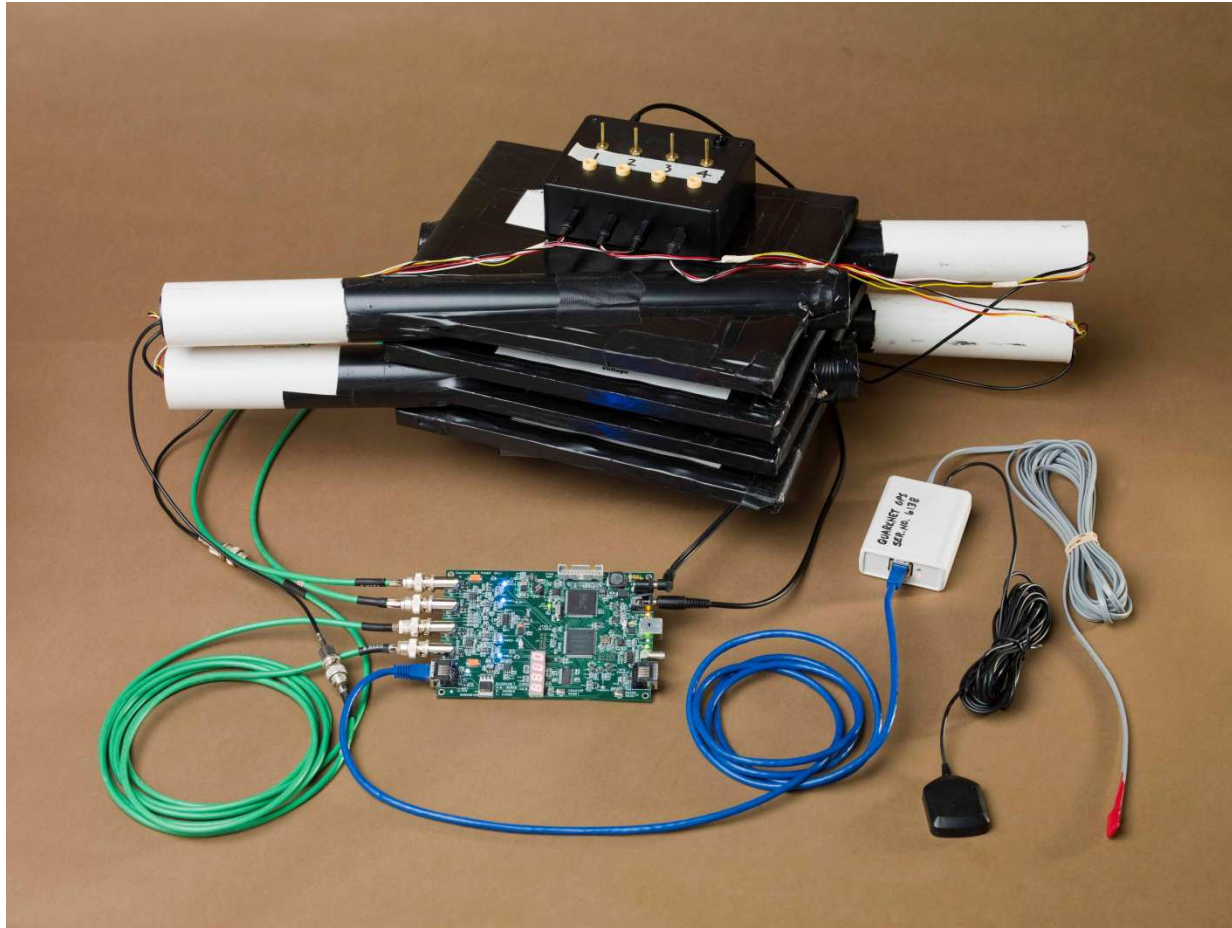


Particle Physics In the Classroom

- Cosmic rays:
 - Fundamental subatomic particles (mostly muons)
 - Produced when high energy protons from distant galaxies hit atoms in the upper atmosphere.

“Where do they come from? I can’t say.
But I bet that have come a long, long way.”
– Dr. Seuss
 - The study ***fundamental particle physics*** began with the discovery of cosmic rays and is ongoing.
 - With the right equipment (which we can provide) you can study cosmic rays in your classroom.
 - You can do the same experiments that yielded Nobel prizes

QuarkNet Cosmic Ray Detector



Same technologies used in modern particle physics experiments.

Cosmic Ray Detector Interface

Control Panel Rates Performance Flux Muon lifetime Air shower Geometry

Serial port: COM1 Log file: CosmicRayDetector_7-9-2012_15:51:16.txt

S/N: 6113 Update Reset scalars Reset board GPS

Help: Page 1 Page 2 Barometer Status Trigger Setup Voltages GPS Lock

GPS status: A (valid) Sats used: 8 T= 30.6 deg C P= 1024 hPa
Latitude: 40-25.823090 N Longitude: 086-54.786453 W
Altitude: 210.012m Time: 09/07/12 19:52:29.022

Scalars: 244939 275680 187630 161602 26268

Control registers: 2F 71 32 00

Timing registers: 00 4B 50 00

Gate width: 500 ns Pipeline delay: 50 ns

Threshold: 250 250 250 250

Status output: With scalars time interval: 5 min

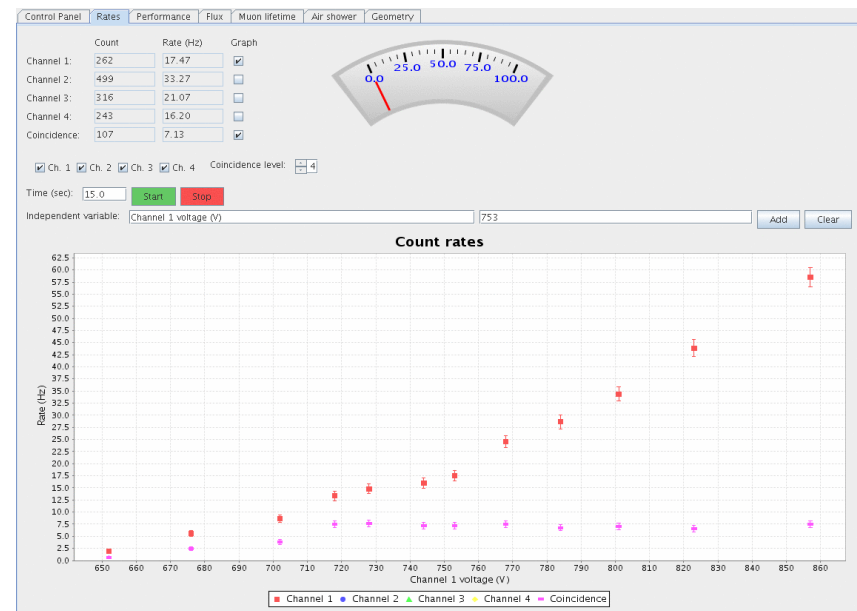
Data output: Enable Disable

Test pulser: Off Once Continuous Voltage: 3000 mV

Command:

Interacting with the cosmic ray detector hardware used to be a challenge...

... but not any more!

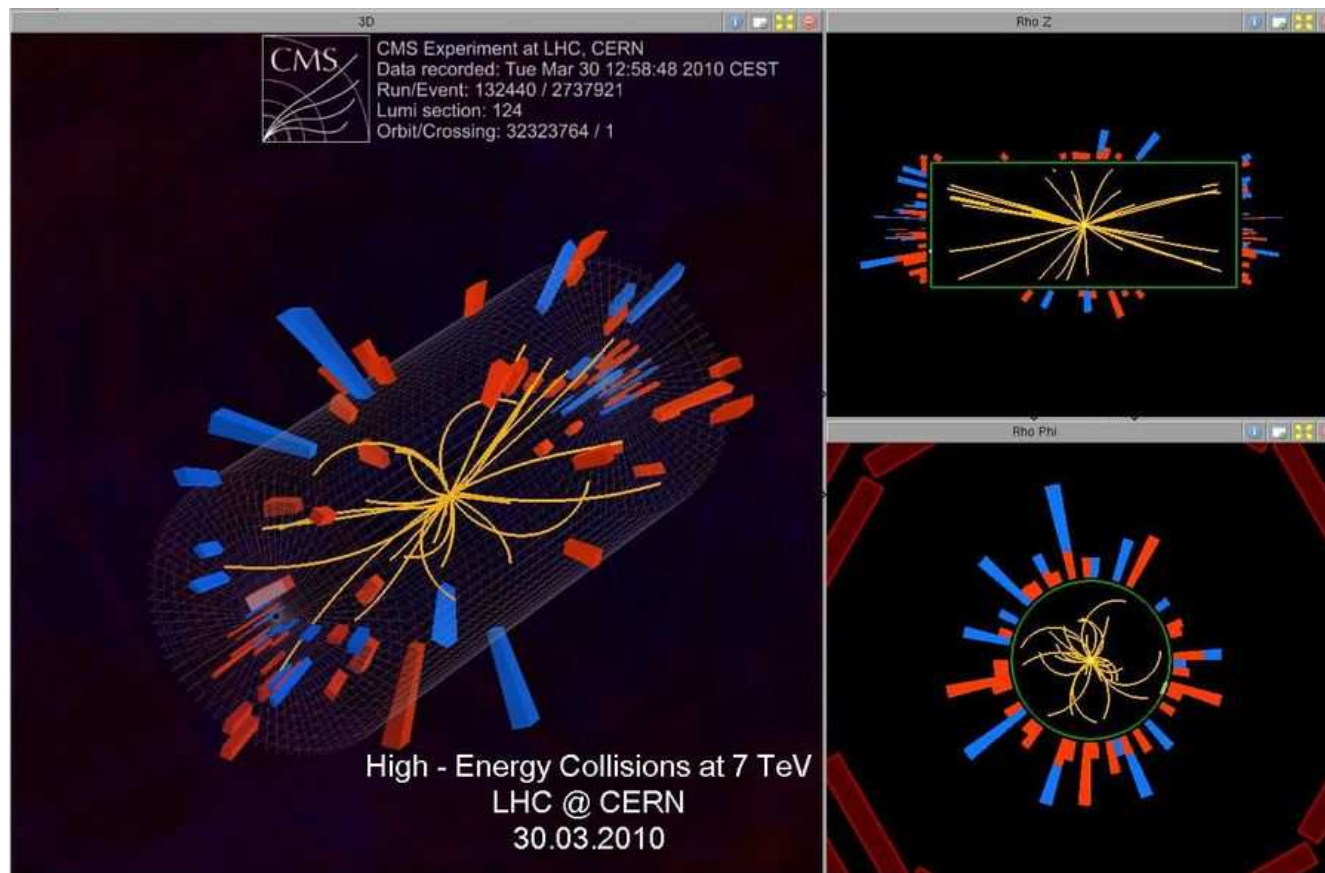


We hope to base many of the activities with the cosmic ray detector on this software interface.

MasterClass Workshops

- We can also analyze data collected with the CMS detector at CERN:
 - Students visit Purdue on a Saturday
 - Analyze data from high energy proton collisions collected with the CMS detector
 - Learn to identify muons, electrons, jets, junk, ...
 - Measure stuff and interpret their measurements
 - Video conference with other centers around the world to compare results.

MasterClass Workshops



Impact on Students

- Do students really need to know about cosmic rays and particle physics?
 - Most probably don't...
- Studying cosmic rays is a model for almost any area of leading edge research:
 - We can't directly see cosmic rays, the Higgs boson, cell walls, gravitational lenses, DNA replication, black holes, tectonic plates, etc., but we learn about them using technology to extend our senses
 - It provides lots of concrete examples of analyzing real research questions using sound principles of deductive reasoning